Letters to the Editor

The Board of Editors does not hold itself responsible for opinions expressed in the letters published in this section. The notes containing short reports of original investigations communicated to this section should not contain many figures and should not exceed 500 words in length. The contributions reaching the Secretary by the 15th of any month may be expected to appear in the issue for the next month. No proof will be sent to the author.

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ON NUCLEAR EXCITATION AND FORMATION ENERGIES IV

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It has been shown in the previous communication-III (Dutta and others, 1964) that the binding energy of weakly bound nuclei is measured in terms of the deviation in energy from the isobaric nucleus, with optimum energy and neutron content, caused by one or more neutron proton exchanges, in accordance with the relation,

$$E = E_0 - \beta(N-N_0)^2 = E_0 - \beta\{N-N_0+\eta(\Delta N)\}^2, \text{ where,}$$
$$E_0 = B(A)+F(I)+F(Z) = B(A)+a_z \cos \pi f(Z)+a_1 \cos \pi f(I).$$

The neutron proton exchange energy β, may be ascertained directly from the binding energy data (Konig *et al*, 1962) by relation (*c*), as shown in the previous communication III. It has also been found that the β values for different mass members are composed of two parts one dependent on A only and the other dependent primarily on the periodically varying potential energy curve $F(Z)$ and also on $F(I)$, to some extent. The strong enhancement of β values at the minima of the $F(Z)$ potential curve and a decrease at the maxima, makes the behaviour of neutron proton exchange energy β similar to the expected change for the general process of excitation energy. As such it was considered worthwhile to compare the β values with the excitation energies of the nuclei. It was recognised that on account of the fundamental difference in odd mass and even mass nuclear structure, the excitation energies for them should be studied in separate groups. We have taken the 1st and 3rd excitation energies for the most strongly bound odd and even mass nuclei, (Nuclear data sheets, 1962), as a first step, and have plotted them alongside the β values, against a mass number scale, The similarity of all the excitation energies with the β values, both in respect of their dependence on A as also in respect of their dependence on the periodic potential energy curves is evident from Fig. I, and may be regarded to be of significance.

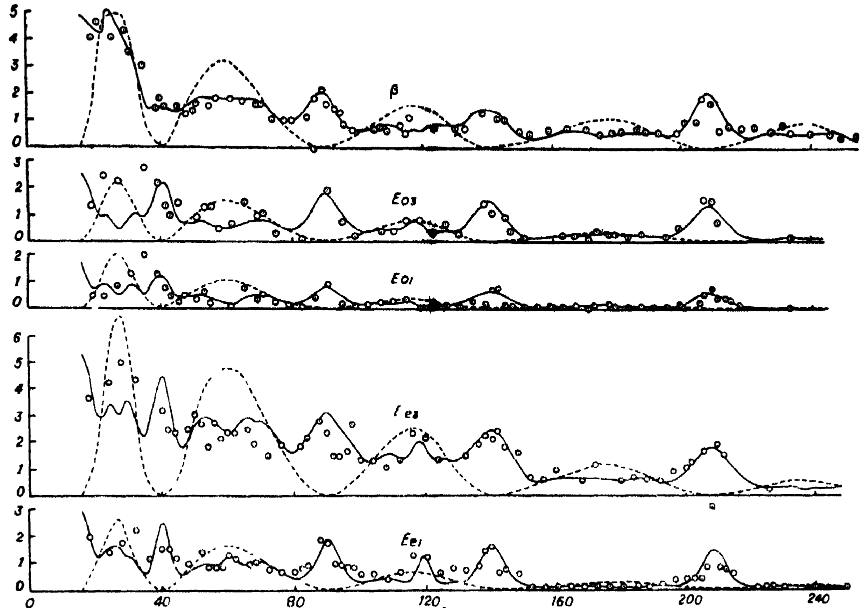

Fig. 1

In view of the close resemblance of the curves for the excitation energies and the neutron proton exchange energies against mass numbers, we may describe them by a general form of relationship, as

$$E_i = \epsilon_i(A, f(Z)) + \epsilon_i(A, A_{z, min}) - \epsilon_i(A, A_{z, max}) + \epsilon_i(A, A_{1, min})$$
$$= (a_0 + b_0 e^{-\alpha_0 A})(1 + \cos \pi f(Z)) + (a_1 + b_1 e^{-\alpha_1 A}) e^{-k_1 \alpha_z (A - A_{1,min})^2}$$
$$-(b_2 e^{-\alpha_z A}) e^{-\alpha_z (A - A_{zmax})^2} + \Sigma_j c_j e^{-\gamma_j (A - A_j)^2}$$

The values so calculated and the experimental values are shown in Fig. 1. Here, the suffix i, stands for the character of excitation, e.g., even 1, odd 3, $\beta(\Delta N = 1)$, etc; A, $f(Z)$, $A_{z\,min}$ etc. in the paranthesis indicate the dependence of energy on A, $f(Z)$ and the maxima or minima positions of the $f(Z)$ function in mass numbers. It also depends on a_z, the amplitude of the $F(Z)$ function at the minima positions, for the β values. In the case of β values for ΔN different from 1, all components except $(a_0 + b_0 e^{-\alpha_0 A})$, the A dependent part, is to be multiplied by the factor σ, where

$$\sigma(\Delta N) = 0.6 + 0.6 \tanh(1.6 - 0.8 \Delta N),$$

the same relation as obtained before.

The constant $a_0 = 0$, except for β, where it obtains the magnitude 0.425, the constants b_1 and α_1 are the same as b_0 and α_0 except for β, where the factor $(a_1+b_1e^{-\alpha_1 A})$ is replaced by $0.125a_z$; the constant α_z, determining the shape of the Gaussian distribution of energy at the maxima and the minima positions of the $f(Z)$ function is of magnitude $40/(\Delta T)^2$, in all cases, where ΔT is the complete period in mass number scale at the respective minima and maxima positions of the $f(Z)$ function. The A_j values replacing $A_{1, min}$ are contributing at some minima only and are slighly displaced from the minima positions. The remaining constants, which vary, are given in the tabulated form below :—

TABLE I

Constants for β and excittion energies

E_i	b_0	$a_0\times 10^2$	a_1	k_1	b_2	$a_2\times 10^2$	C_1	C_2	γ_r	A_1	A_2
E_{01}	1.6	1.800	0.5	2.5	2.21	1.443	0.30	0.15	.074	115	176
E_{o3}	1.5	1.171	1.3	2.0	2.44	1.421	0.50	0.2	.154	117	178
E_{e1}	2.0	1.555	1.4	3.125	1.38	1.097	0.45	1.0	.167	61	119
E_{e3}	4.7	1.138	1.4	1.25	4.78	1.180	0.0	0.92	.167	61	118
$\beta(\frac{\Delta N}{-1})$	3.64	1.950	0.0	2.0	2.16	0.723	4.53	0.0	.002	0	0

The expression for β, as stated now, changes the form of representation of its magnitude, used in communication III, before. Along with it, we also modify the analytical expressions for some of the components of E_0, namely $f(Z)$, a_1 and ϕ, to obtain the different contributory parts of E_0 in a more regular shape. The expressions for the components of E_0 and thus of the binding energies of all nuclei, may be put as follows. The expression for N_0 remains unaltered.

Relations :

$$B(A) = -9.828A+8.877\times 10^{-3}A^2+C_{ij} \text{ mev.}$$

$$C(ee) = 32.2;\ C({}^{e}_{o}{}^{o}_{e}) = 33.0;\ C(oo) = 34+80A^{-1} \qquad \ldots (1)$$

$$N_0^* = 0.6302A-0.1287A \exp(-7.95\times 10^{-3}.A)-.00155A$$
$$\times \cos \pi\{0.794 \sinh .0372(A-104)\}\{1-\tanh .6(A-45)\}$$
$$\times\{1-\tanh. 6(A-145)\}$$

$$\eta(\Delta N) = 0.1\,|N_0^*-N|-0.1 \qquad \ldots (2)$$

$$f(Z) = -.051+0.0339A-2. \exp -1.18\times 10^{-3}.A^2+0.311 \exp -2.25\times 10^{-3} (A-144)^2.$$

$$a_z = 10.9-2.9\{\sin \pi\, 0.5f(Z)-\Sigma_i \exp-\alpha_i(A-A_i(F_z \min))^2\};\ \left[\alpha_i = \frac{200}{T^2}\right]$$

$$a_1 = 10-3 \sin \pi \{\tanh \alpha_1(A-116)\}; \quad [\alpha = .013] \qquad \ldots \quad (3)$$

$$\phi = 1.052+.088 \sin \pi(\exp \gamma\, A);$$

$$\gamma_i = \begin{cases} 6.196 \times 10^{-3}, & A < 170 \\ 6.836 \times 10^{-3}, & A > 170 \end{cases}$$

β — as described above.

The graphical representation of $B(A)$, $F(Z)$ and $F(I)$ are shown in Fig. 2.

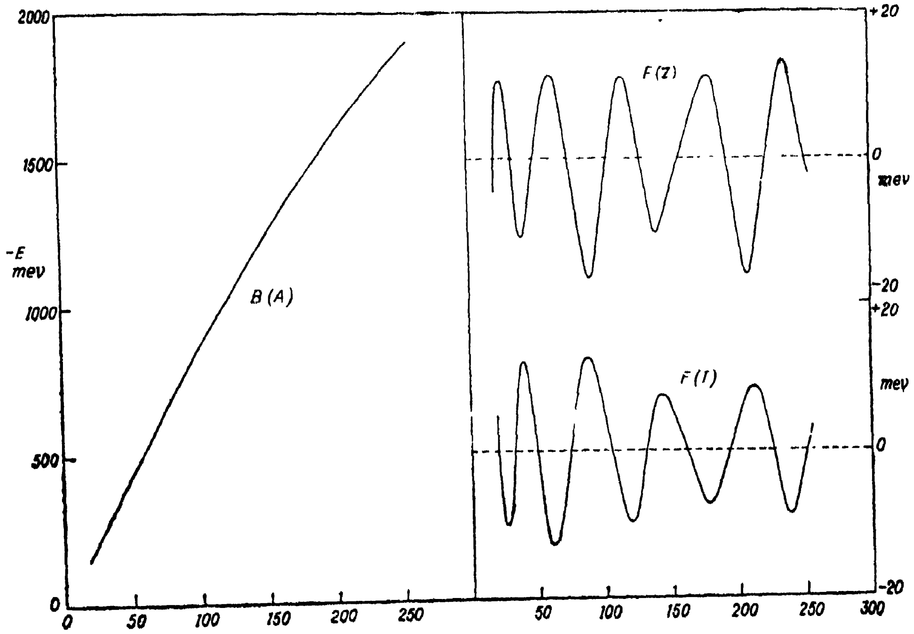

Fig. 2.

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